Design of Microstrip Log Periodic Antenna for Wireless Applications

A thesis submitted in partial fulfillment of the requirements for the Degree of Bachelor of Technology

In

Electronics and Communication Engineering

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CERTIFICATE

This is to certify that the work in the thesis entitled **"Design of Microstrip Log Periodic Antenna for Wireless Application"** by **Abhishek Halder** & **Sandeep Kumar Pradhan**, is a record of an original research work carried out by them under my supervision and guidance in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** in **Electronics and Communication Engineering** at the **National Institute of Technology, Rourkela**. To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/ Institute for the award of any degree or diploma.

DATE:13.05.2013 Dr. S. K. Behera

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ABSTRACT

An antenna is a basic component of any communication device required for both transmitting as well as receiving of the signal. Starting from Radio or Television transmission to satellite communication, be it Wi-Fi or Bluetooth or mobile phone network; all these technologies would not have been possible without the development of antennas. In Government and Commercial applications like mobile or wireless communication, high performance aircrafts, satellites and missile applications, where size, cost, weight, performance, etc. are the constraints, low profile antennas such as Microstrip Antennas are used.

The Microstrip Antenna (MSA) that we have designed can work on an ultra-wide band. A MSA has many attractive features like low profile, light weight, small volume and low production cost. In addition, integrating the Microstrip line feed structure with the radiating elements on the same substrate attains the benefit of a compact, low lost feed network. So to enhance the narrow bandwidth, log periodic concept is being used. Log periodic antenna is important with their ability to show nearly frequency independent characteristics over wide band of frequencies although they have relatively simple geometries. The MLPA contains 8 pairs of parallel elements on both sides of the microstrip feed line runs along the centre of the antenna. The range of MLPA is from 2.824 GHz to 5.253 GHZ (with a Band width of 29.921%). Test results shows that the antenna can operate at S/C bands with voltage standing wave ratio (VSWR) less than 2 and high directional radiation patterns. This antenna can be used for satellite communication, amateur radio broadcasting, providing Wi-fi channels etc.

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Chapter 1 Introduction and Overview

1.1 Introduction

An antenna can be explained as a transitional structure between free space and a guiding device. Consider a basic mobile phone or a TV or even a radio; all of these devices contain a simple, low profile, light weight, low cost device for transmission and reception of signals called a microstrip antenna. Microstrip antennas have developed considerably during the past few decades, which have helped in overcoming many of its limitations. There has been a series of developments in the feeding techniques size, thickness, materials, and design. These developments have helped us in increasing the bandwidth and the gain of the antennas. Reducing in the size of the antenna makes it portable and more convenient to use. Microstrip antennas being easy to design and manufacture are used in various fields where low profile antennas are required.

1.2 Objective

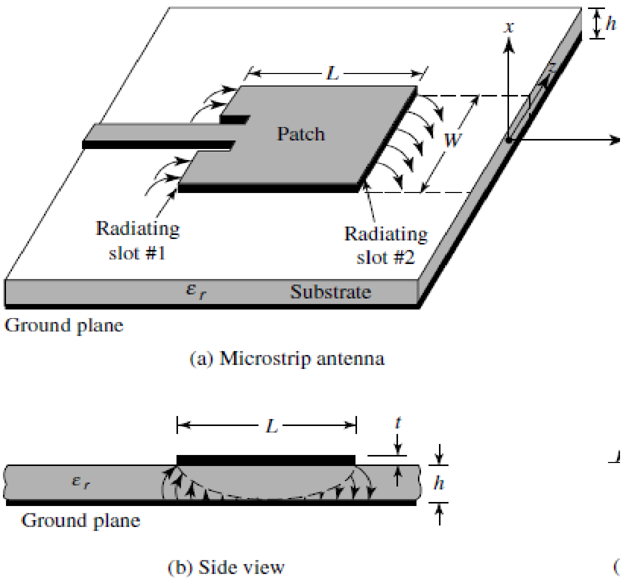
The project is aimed at designing a Microstrip Antenna (MSA) which can work on an ultra-wide band. The MLPA contains 8 pairs of parallel elements on both sides of the microstrip feed line runs along the centre of the antenna. The observations were made based on radiation pattern, bandwidth, return loss, VSWR and gain and the results were noted down. The design was modified considering the necessary constraints to get the optimum results.

Chapter 2 Theory related to Antenna

2.1 Microstrip Antenna

Microstrip antennas, as shown in figure: 1, consists of a very thin metallic strip (patch) placed a small fraction of a wavelength above a ground plane. The microstrip patch is designed so its pattern maximum is normal to the patch. This is accomplished by properly choosing the mode of excitation beneath the patch. For rectangular patch, the length L of the element is usually λ0/3 < L < λ0/2.The strip (patch) and the ground plane are separated by a dielectric sheet (substrate) as shown in figure2.1a.

Fig: 2.1 Different views of a Microstrip



There are numerous substrates that can be used for the design of microstrip antennas, and their dielectric constants are usually in the range of 2.2 ≤ €r ≤ 12.The ones that are most desirable for antenna performance are thick substrates whose dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space, but at the expense of larger element size. Thin substrates with higher dielectric constants are desirable for microwave circuitry because they require tightly bound fields to minimize undesired radiation and coupling, and lead to smaller element sizes; however, because their greater losses, they are less efficient and have relatively smaller bandwidths. Since microstrip antennas are often integrated with other microwave circuitry, a compromise has to be reached between good antenna performance and circuit design.

Often microstrip antennas are also referred to as patch antennas. The radiating elements and the feed lines are usually photo etched on the dielectric substrate. The radiating patch may be square, rectangular, thin strip (dipole), circular, elliptical, triangular or any other configuration. These and others are illustrated in figure: 2.Square, rectangular, dipole(strip), and circular are the most common because of ease of analysis and fabrication, and their attractive radiation characteristics, especially low cross-polarization radiation. Microstrip dipoles are attractive because they inherently possess a large bandwidth and occupy less space, which makes them attractive for arrays. Linear and circular polarizations can be achieved with either single elements or arrays of microstrip antennas [1].

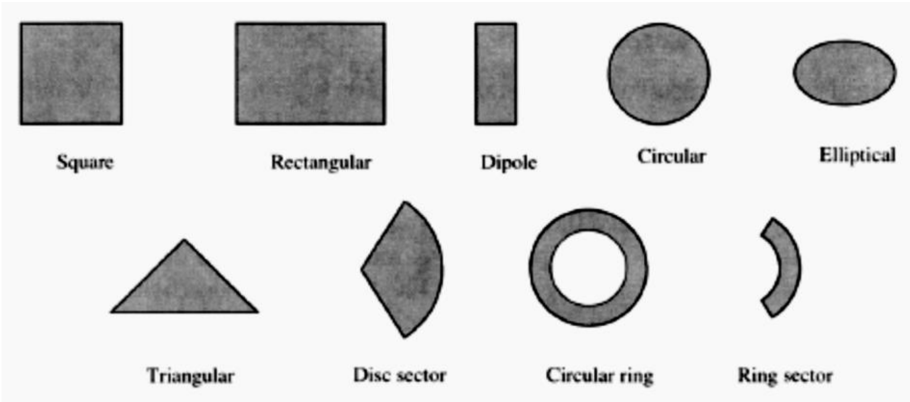


Fig: 2.2 Representative shapes of Microstrip patch

2.2 Advantages and Disadvantages

Some of their principal advantages are given below:

• Light weight and low fabrication cost.

• Supports both, linear as well as circular polarization.

• Can be easily integrated with microwave integrated circuits.

• Capable of dual and triple frequency operations.

• Mechanically robust when mounted on rigid surfaces.

Microstrip patch antennas suffer from more drawbacks as compared to conventional antennas. Some of their major disadvantages are given below:

• Narrow bandwidth.

• Low efficiency and Gain.

• Extraneous radiation from feeds and junctions.

• Low power handling capacity.

• Surface wave excitation[2-3].

2.3 Feeding Methods

There are many configurations that can be used to feed microstrip antennas. The most popular are the microstrip line, coaxial probe, aperture coupling and proximity coupling. These are displayed in figure 3.The microstrip line feed is easy to fabricate, simple to match by controlling the inset position and rather simple to model. However as the substrate thickness increases surface waves and spurious feed radiation increases, which for practical designs limit the bandwidth (typically 2-5%). Coaxial-line feeds, where the inner conductor of the coax is attached to the radiation patch while the outer conductor is connected to the ground plane, are also widely used. The coaxial probe feed is also easy to fabricate and match, and it has low spurious radiation. However, it also has narrow bandwidth and it is more difficult to model, especially for thick substrates (h>0.02 $\lambda 0$).

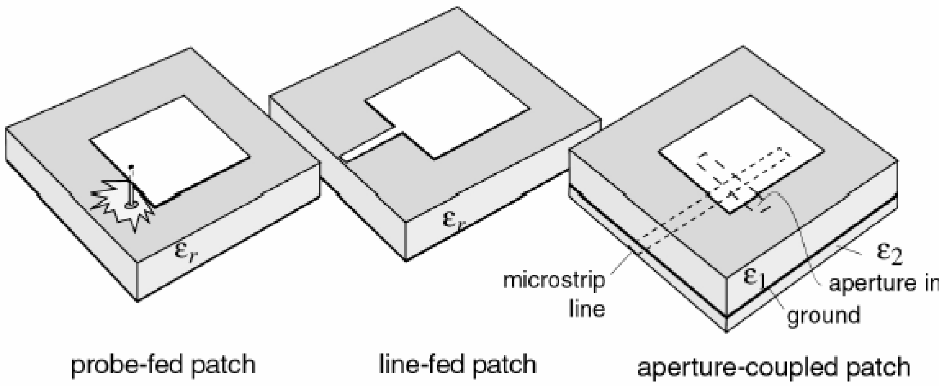


Fig: 2.3 Typical feeds for Microstrip antennas

Both the microstrip feed line and the probe possesses inherent asymmetries which generate higher order modes which produce cross-polarized radiation. To overcome some of these problems, non-contacting aperture coupling feeds, as shown in figure: 3 have been introduced. The aperture coupling of figure: 3 are the most difficult of all four to fabricate and it also has narrow bandwidth.

However, it is somewhat easier to model and has moderate spurious radiation. The aperture coupling consists of two substrates separated by a ground plane. On the bottom side of the lower substrate there is a microstrip feed line whose energy is coupled to the patch through a slot on the ground plane separating the two substrates. This arrangement allows independent optimization of the feed mechanism and radiating element. Typically a high dielectric material is used for the bottom substrate, and thick low dielectric constant material for the top substrate. The ground plane between the substrates also isolates the feed from the radiating element and minimizes interference of spurious radiation for pattern formation and polarization purity [1].

2.4 Rectangular Patch

The rectangular patch is by far the most widely used configuration. It is very easy to analyse using both the transmission-line and cavity models, which are most accurate for thin substrates [1].

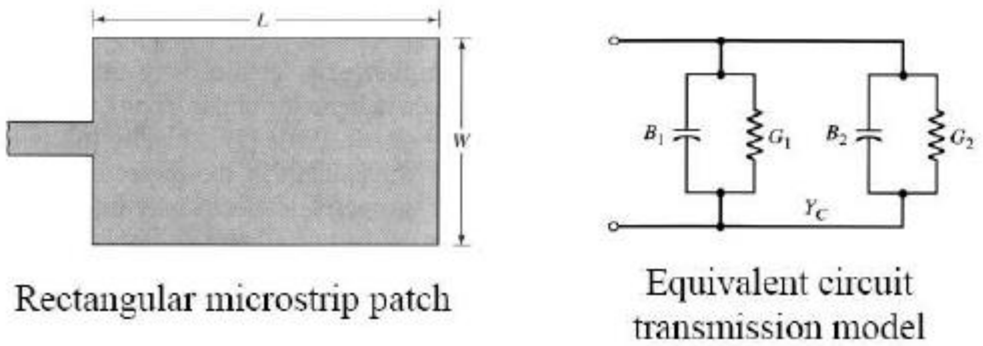
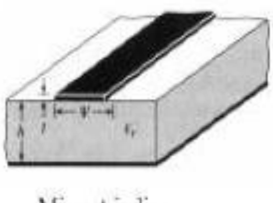


Fig: 2.4 Rectangular Microstrip patch and its equivalent circuit transmission model

2.4.1 Fringing Effects

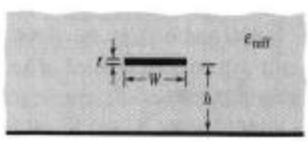
Because the dimensions of the patch are finite along the length and width, the fields at the edges of the patch undergo fringing. This is illustrated along the length in figure: 1& 5 for the two radiating slots of the microstrip antenna. The same applies along the width. The amount of fringing is a function of the dimensions of the patch and the height of the substrate. For the principal E-plane (xy-plane) fringing is a function of the ratio of the length of the patch L to the height h of the substrate (L/h) and the dielectric constant ϵ_r of the substrate. Since for microstrip antennas L/h >> 1, fringing is reduced however it influences the resonant frequency of the antenna. For a microstrip line shown in figure: 5, typical electric field lines are shown in figure: 6.This is a nonhomogeneous line of two dielectrics typically the substrate and air. The most of the electric field lines reside in the substrate and parts of some lines exist in air. As L/h >> 1 and ϵ_r >> 1, the electric field lines concentrate mostly in the substrate. Fringing in this case makes the microstrip line look wider electrically compared to its physical dimensions. Since some of the waves travel in substrate and some in air, an effective dielectric constants ϵ_{reff} is introduced to account for fringing and the wave propagation in the line.

To introduce the effective dielectric constant, let us assume that the centre conductor of the microstrip line with its original dimensions and height above the ground plane is embedded into one dielectric, as shown in figure:7.The effective dielectric constant is defined as the dielectric constant of the uniform dielectric material so that the line of figure:7 has identical electrical characteristics, particularly propagation constant, as the actual line of figure:5.For a line with air above the substrate, the effective dielectric constant has values in the range of $1<\epsilon_{reff}< \epsilon_r$. For most applications where the dielectric constant of the substrate is much greater than unity (ϵ_r>> 1), the value of ϵ_{reff} will be closer to the value of the actual dielectric constant ϵ_r of the substrate. The effective dielectric constant is also a function of frequency. As the frequency of operation increases, most of the electric field lines concentrate in the substrate. Therefore the microstrip line behaves more like a homogeneous line of one dielectric (only the substrate), and the effective dielectric constant approaches the value of the dielectric constant of the substrate. Typical variations, as a function of frequency, of the effective dielectric constant for a Microstrip line with three different substrates are shown in figure: 5, 6 & 7 [1].



Microstrip line

Electric field lines of a microstrip line



Effective dielectric constant geometry of a microstrip line

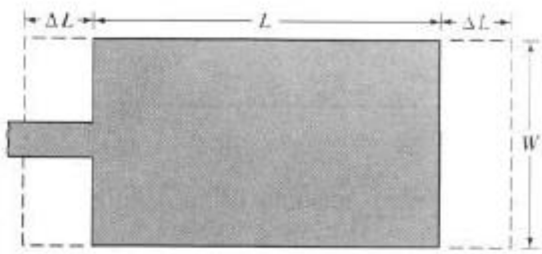
For $\frac{W}{h} > 1$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\sqrt{(1 + 12\frac{h}{w})} \text{ -------------------------- } (1)$$

2.4.2 Effective Length Resonant Frequency and Effective Width

Because of the fringing effects, electrically the patch of the Microstrip antenna looks greater than its physical dimensions. For the principal E-plane (xy-plane), this is demonstrated in figure: 8 where the dimensions of the patch along its length have been extended on each end by a distance ΔL, which is a function of the effective dielectric constant Єref and the width-to-height ratio (W/h) [1].

Since the length of the patch has been extended by ΔL on each side, the effective length of the patch is now Leff =L + 2 ΔL ---------------------- (2)



Physical length of a rectangular patch

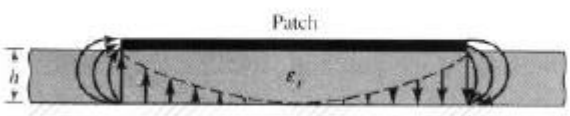


Fig: 2.6 a,b Fringing effects and effective length of a rectangular patch

2.5 Log Periodic Antenna

A log periodic antenna is a broadband, directional, multi-element, narrow-beam antenna that has radiation and impedance characteristics which are regularly repetitive as a logarithmic function of the excitation frequency.

The log periodic antenna was invented by Dwight E'Isbell, Raymond Duhamel and variants by Paul Mayes. The University of Illinois at Urbana-Champaign had patented the Isbell and Mayes-Carrel antennas and licensed the design as a package exclusively to JFD electronics in New York. Lawsuits regarding the antenna patent which the UI Foundation lost, evolved into the Blonder-Tongue Doctrine

It is well known and very much attractive due to its frequency independent nature. The log-periodic antenna is attractive for use in wide-band arrays due to its an end-fire structure, its physical aperture (normal to the main-beam direction) is smaller than the other designs. However, it is undoubtedly obvious that the standard form of the antenna will lead to severe dispersion of the frequency components in a pulsed waveform. This is due to the antenna excitation at the "nose" (the front end nearest to the shortest dipole element) and low-frequency components of the signal have to travel down the antenna structure until they reach a dipole that is near resonance. They have to travel back the same distance as radiated fields before they can combine with the high-frequency components radiated from short dipole elements near the feed. This results in a time delay which is approximately proportional to the wavelength of the component. One of the prominent advantage of these antennas is the straight forward design procedure which facilitates their engineering application.
The design and construction of a LPA antenna for ultra-wide band applications is extremely difficult. The antenna would have low portability and its installation would be expensive and complicated. A reconfigurable log-periodic antenna, built using inexpensive and reusable materials can be used in UWB applications with minimum size and cost. It would be possible to operate in many distinct frequency bands like S band, C band, X band. The possibility of reconfiguring so many physical parameters in the same log-periodic antenna is difficult.

Another advantage of LPA is that for the same frequency band it will be possible to obtain different gains through the adjustment of its elements. Antenna measurements over extensive frequency bands can be related to time-domain responses to pulses, eliminating through computer processing multipath effects and other interferences. A LPA antenna has an educational application, being an interesting acquisition for antenna teaching laboratories in developing countries. A LPA antenna project or experiment could be easily implemented requiring only the reconfiguration of the antenna and not being necessary to build a newer one [1].

2.5.1 Design Parameters

It is consist of a metal strip whose element edges are specified by the apex angle 2α. In order to specify the lengths of elements on the structure from origin, distance characteristics must be included in the process. The geometric ratio of the antenna is given by[3-4]

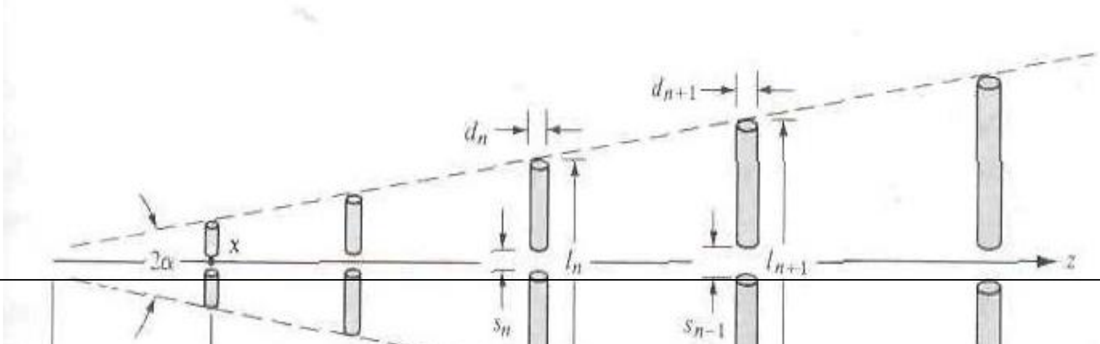
$$\tau = R_n/(R_{n+1})$$

The geometric ratio τ also defines the operation period of the antenna. If two frequencies f1 and f2 are one period apart, they are related by

$$\tau = f_1/f_2 \quad , f_2 > f_1$$

The geometrical dimensions of the antenna the lengths ln, spacing Rn, gap spacing at dipole centres Sn, diameters dn of the LPA is given by the inverse of the geometric ratio τ[5-8].

$$1/\tau = l_{n+1}/l_n = R_{n+1}/R_n = d_{n+1}/d_n = S_{n+1}/S_n$$

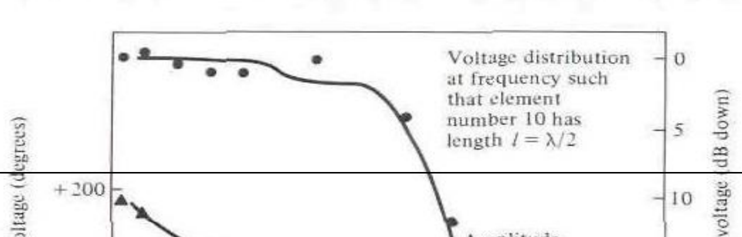


The spacing factor is given by:

$$\boldsymbol{\sigma}=R_{n+1}-R_n/2l_{n+1}$$

Straight lines through the dipole ends meet to form an angle 2α which is a characteristics of frequency independent structures. If the additions of the elements are closely spaced, the phased progression of the currents is to the right which produces an end fore in the direction of the longer elements and interference effects to the pattern result. A 180^0 phase is added to the terminal of each element since the phase between the adjacent closely spaced short elements is in opposition, very little energy is radiated by those elements and their interference effects are negligible. At the same time, shorter and longer elements are radiated. The mechanical phase reversal between elements produces a phase progression the energy is end fired in the direction of shorter elements.

The cut-off frequencies of the truncated structure can be determined by the electrical lengths of the longest and shortest elements of the structure. The lower cut-off frequency occurs when the longest element is λ/2. The high cut off frequency occurs when this shortest element is nearly λ/2 only when the very narrow active region. The active region of the LPA is near the elements whose lengths are nearly or slightly smaller than λ/2. The energy from the shorter active elements travelling toward the longer elements decreases very rapidly so that a very negligible amount of energy is reflected from the truncated end. The movement of the active region of the antenna is an undesirable characteristic in the design of feeds.



The decrease of energy towards the longer inactive elements is demonstrated above

The periodicity of the structure does not ensure operation of broadband rather the variations of the impedance, pattern and directivity for the corresponding bandwidth of the cycle, broadband characteristics are ensured within the acceptable limits of variation.

The relative span of each cycle is given by

$$\Delta = \ln(f2) - \ln(f1) = \ln(1/\tau)$$

The variations will occur within a given cycle will repeat identically at other cycles of the bandwidth.

The design of LPA have apex angles of $10^0 <= \alpha <= 45^0$

and

the geometric ratio of $0.95 >= \tau >= 0.7$.

As α increases the corresponding τ value decreases and vice versa.

Larger values of or smaller values of τ result in more compact designs which require smaller number of elements separated by larger distances. Smaller values of or larger values of τ require a large number of elements that are closer together . There are more number of elements in the active region of this design. So, the variations of the impedance and other important characteristics as a function of frequency are smaller due to the smoother transition between the elements and larger gains [1].

2.6 Antenna Parameters

2.6.1 GAIN

Gain is a parameter which measures the degree of directivity of the antenna's radiation pattern. A high-gain antenna will preferentially radiate in a particular direction. The antenna gain or power gain of an antenna is defined as the ratio of the intensity (power per unit surface) radiated by the antenna in the direction of its maximum output at an arbitrary distance divided by the intensity radiated at the same distance by a hypothetical isotropic antenna [2].

2.6.2 RADIATION PATTERN

The radiation pattern of an antenna is a plot of the relative field strength of the radio waves emitted by the antenna at different angles. It is represented by a three dimensional graph or polar plots of the horizontal and vertical cross sections. The pattern of an ideal isotropic antenna, which radiates equally in all directions, would look like a sphere. Many non-directional antennas, such as monopoles and dipoles, emit equal power in all horizontal directions, with the power dropping off at higher and lower angles; this is called an omnidirectional pattern and when plotted looks like a torus or donut.

The radiation of many antennas shows a pattern of maxima or "lobes" at various angles separated by "nulls", angles where the radiation falls to zero. This is because the radio waves emitted by different parts of the antenna typically interfere, causing maxima at angles where the radio waves arrive at distant points in phase, and zero radiation at other angles where the radio waves arrive out of phase. In a directional antenna designed to project radio waves in a particular direction, the lobe in that direction is designed larger than the others and is called the "main lobe". The other lobes usually represent unwanted radiation and are called "side lobes". The axis through the main lobe is called the "principal axis" or "bore sight axis" [2].

2.6.3 EFFICIENCY

Efficiency of a transmitting antenna is the ratio of power actually radiated in all directions to the power absorbed by the antenna terminals. The power supplied to the antenna terminals which is not radiated rather converted into heat. This is through loss resistance in the antenna's conductors but can also be due to dielectric or magnetic core losses in antennas using such components. Such loss effectively robs power from the transmitter requiring a stronger transmitter in order to transmit a signal of a given strength.

Note that antenna efficiency is a separate issue from impedance matching, which may also reduce the amount of power radiated using a given transmitter. If an SWR meter reads 150 W of incident power and 50 W of reflected power that means that 100 W have actually been absorbed by the antenna ignoring transmission line losses. How much of that power has actually been radiated cannot be directly determined through electrical measurements at (or before) the antenna terminals, but would require (for instance) careful measurement of field strength [2].

2.6.4 IMPEDANCE MATCHING

Maximum power transfer requires matching the impedance of an antenna system looking into the transmission line to the complex conjugate of the impedance of the receiver or transmitter. In the case of a transmitter, the desired matching impedance might not correspond to the dynamic output impedance of the transmitter as analysed as a source impedance but rather the design value (typically 50 ohms) required for efficient and safe operation of the transmitting circuitry. The intended impedance is normally resistive but a transmitter may have additional adjustments to cancel a certain amount of reactance in order to "tweak" the match. When a transmission line is used in between the antenna and the transmitter (or receiver), one generally would like an antenna system whose impedance is resistive and near the characteristic impedance of that transmission line in order to minimize the standing wave ratio(SWR) and the increase in transmission line losses it entails, in addition to supplying a good match at the transmitter or receiver itself [3].

2.6.5 EFFECT OF GROUND

Antennas are typically used in an environment where other objects are present that may have an effect on their performance. Height above ground has a very significant effect on the radiation pattern of some antenna types.

At frequencies used in antennas, the ground behaves mainly as a dielectric. The conductivity of ground at these frequencies is negligible. When an electromagnetic wave arrives at the surface of an object, two waves are created: one enters the dielectric and the other is reflected. If the object is a conductor, the transmitted wave is negligible and the reflected wave has almost the same amplitude as the incident one. When the object is a dielectric, the fraction reflected depends (among other things) on the angle of incidence. When the angle of incidence is small (that is, the wave arrives almost perpendicularly) most of the energy traverses the surface and very little is reflected. When the angle of incidence is near 90° (grazing incidence) almost all the wave is reflected [2].

2.6.6 VOTAGE STANDING WAVE RATIO

Standing wave ratio (SWR) is the ratio of the amplitude of a partial standing wave at an antinode (maximum) to the amplitude at an adjacent node (minimum), in an electrical transmission line.

The SWR is usually defined as a voltage ratio called the VSWR, for voltage standing wave ratio. The power standing wave ratio (PSWR) is defined as the square of the VSWR.

SWR is used as an efficiency measure for transmission lines, electrical cables that conduct radio frequency signals, used for purposes such as connecting radio transmitters and receivers with their antennas, and distributing cable television signals. A problem with transmission lines is that impedance mismatches in the cable tend to reflect the radio waves back toward the source end of the cable, preventing all the power from reaching the destination end. SWR measures the relative size of these reflections. An ideal transmission line would have an SWR of 1:1, with all the power reaching the destination and no reflected power. An infinite SWR represents complete reflection, with all the power reflected back down the cable. The SWR of a transmission line can be measured with an instrument called an SWR meter, and checking the SWR is a standard part of installing and maintaining transmission lines [2].

The voltage standing wave ratio is then equal to:

$$\text{VSWR} = 1+ |\tau| / 1-|\tau|$$

$$\text{Where } \tau = (z_{max} - z_{min}) / (z_{max} + z_{min})$$

2.6.7 FRONT TO BACK RATIO

Front-to-back ratio is the ratio of power gain between the front and rear of a directional antenna and ratio of signal strength transmitted in a forward direction to that transmitted in a backward direction.

For receiving antennas, the ratio of received-signal strength when the antenna is rotated 180°.

The ratio compares the antenna gain in a specified direction, i.e., azimuth, usually that of maximum gain, to the gain in a direction 180° from the specified azimuth. A front-to-back ratio is usually expressed in dB

In point-to-point microwave antennas, a "high performance" antenna usually has a higher front to back ratio than other antennas [2].

2.6.8 RETURN LOSS

The return loss is the loss of signal power resulting from the reflection caused at a discontinuity in a transmission line. This discontinuity can be a mismatch with the terminating load or with a device inserted in the line. It is usually expressed as a ratio in decibels (dB);

$$RL(\mathrm{dB}) = 10\log_{10}\frac{P_\mathrm{i}}{P_\mathrm{r}}$$

where RL(dB) is the return loss in dB, Pi is the incident power and Pr is the reflected power. Return loss is related to both standing wave ratio (SWR) and reflection coefficient (Γ). Increasing return loss corresponds to lower SWR. Return loss is a measure of how well devices or lines are matched. A match is good if the return loss is high. A high return loss is desirable and results in a lower insertion loss.

Return loss is used in modern practice in preference to SWR because it has better resolution for small values of reflected wave.

The S-parameter S11 from two-port network theory is frequently also called return loss [2].

Chapter 3 Antenna Design

3.1 Design Parameters

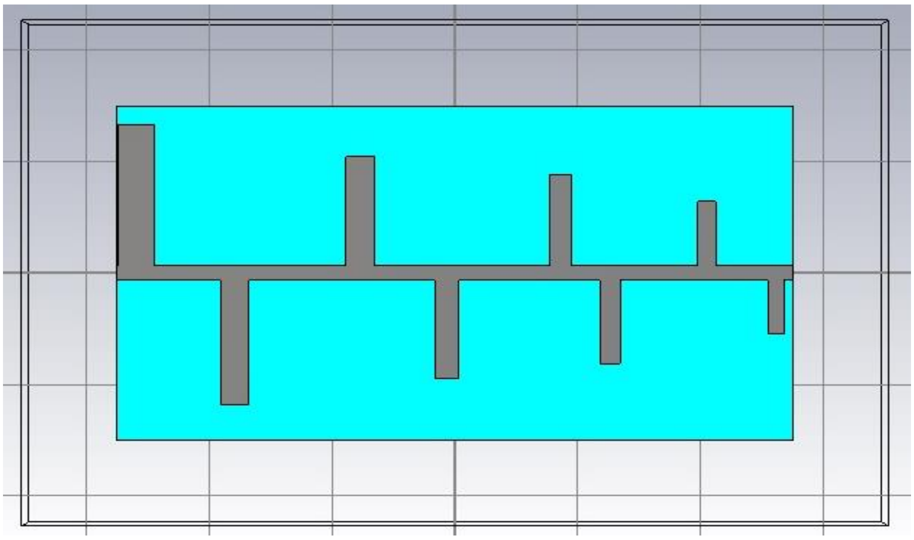
We used CST Microwave Studio 2012 for the purpose of designing and simulation of the antenna. The antenna is designed on a substrate with the dimensions length L=110mm, width W=60mm, height H=1.55mm and had a dielectric constant ϵr=4.4. The metallic patch which acts as an antenna has a thickness h=0.05mm. The port used has a dimension of 16mm X 4mm. PEC (Perfect Electric Conductor) was used to make the patch. The microstrip feed line has a width w=2.9mm. The port is connected directly to the microstrip feed line. The patch has 8 pairs of parallel elements on both side of the microstrip feed line which runs along the centre of the antenna. This structure is present on both sides of the substrate one side acts as the antenna and the other as the defective ground plane. Although the patches on the front and back look same they are not so, they are mirror images of each other. Also the height, width and the distance between these elements maintain a fixed ratio as they have been designed using a log periodic approach.

The optimized parameters of the MLPA are:

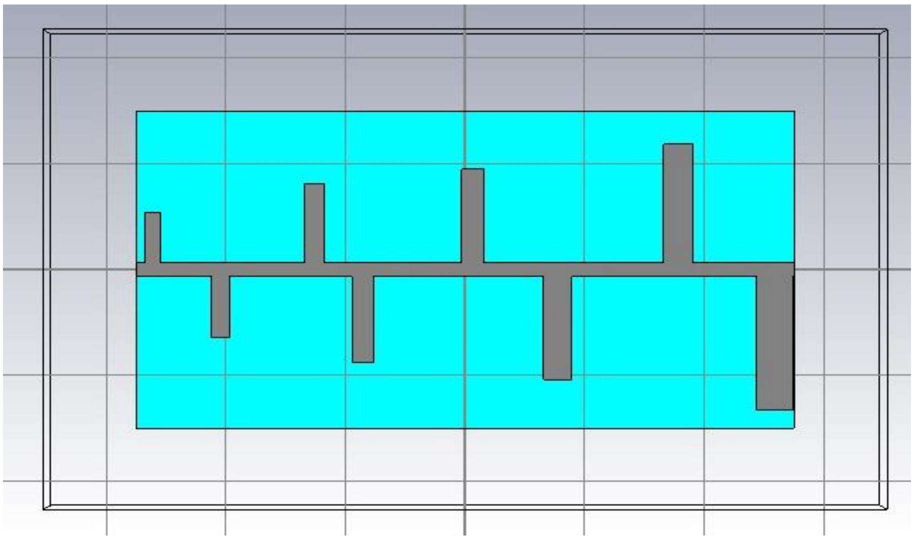
n\Parameters	dn	ln	Sn
1	2.68	20.8	3
2	2.98	25.84	12.71
3	3.24	32.44	13.79
4	3.53	35.26	14.53
5	3.83	38.32	15.56
6	4.17	41.66	16.68
7	4.53	45.28	17.89
8	4.92	49.22	19.22

Table: 3.1

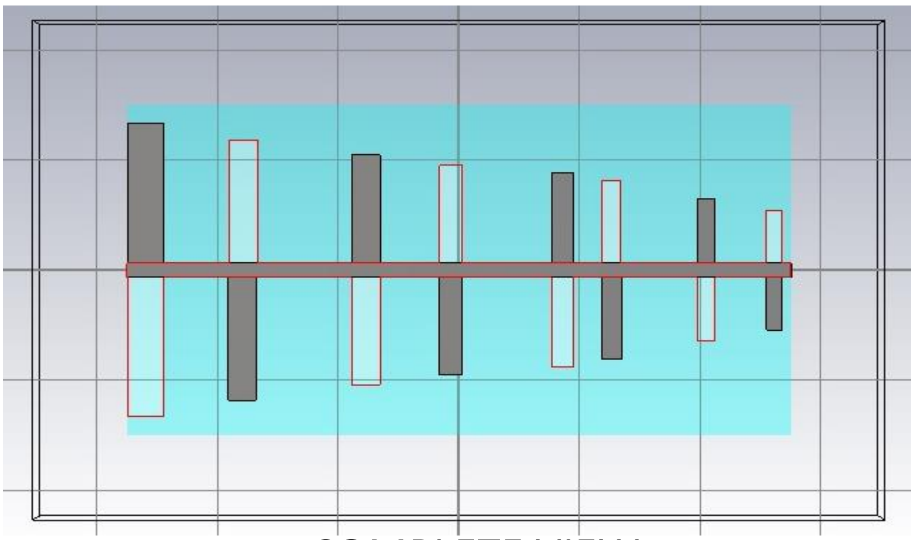
Fig: 3.1 Different views of the antenna



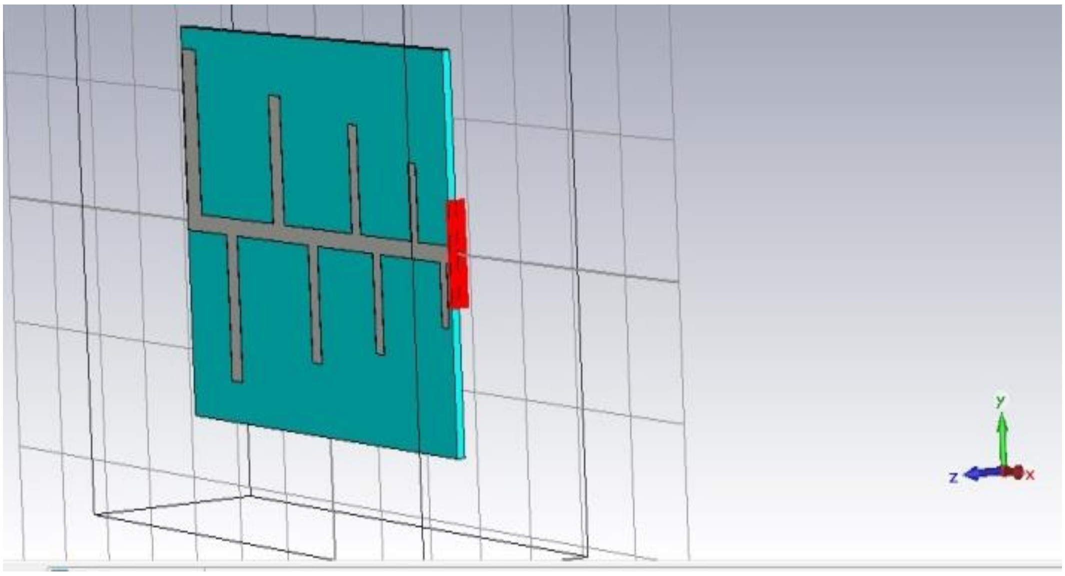
FRONT VIEW



REAR VIEW



COMPLETE VIEW



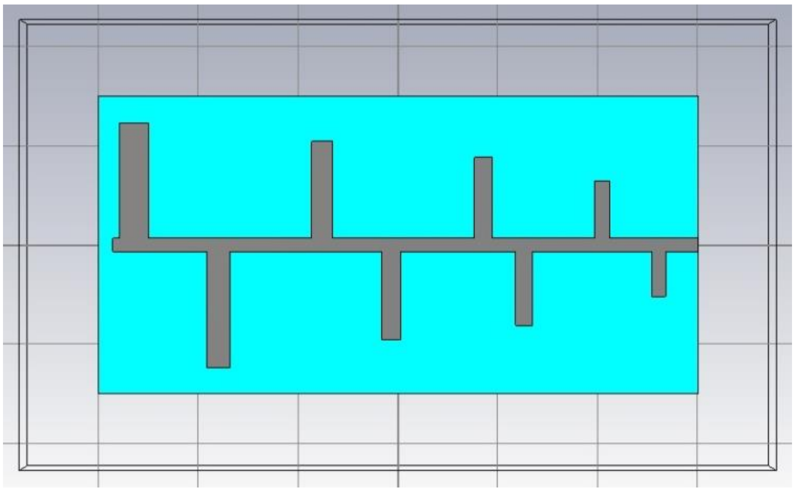
PORT VIEW

3.2 Designing process:

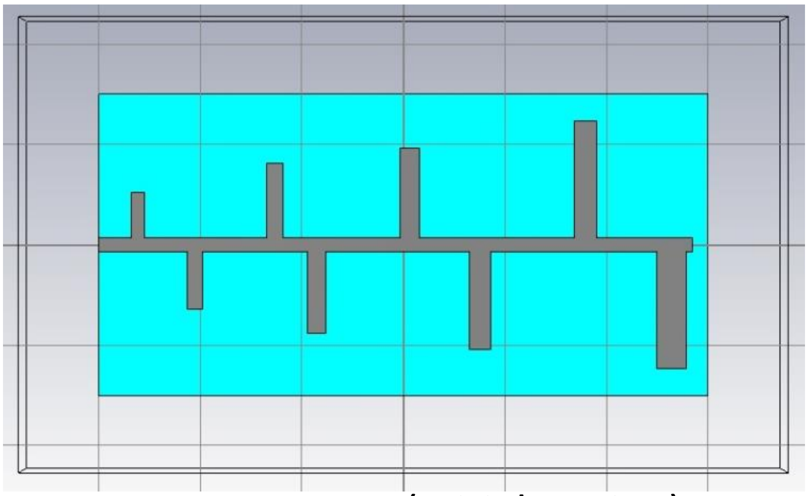
The above antenna shown here is the final design which we could come up to after series of modifications. Now let us discuss how we could come up to this design. The first design was made having a substrate of dimension 120mm X 60mm X 1.55mm and a dielectric constant of 4.4. The patch used then had a thickness of 0.4mm and a port of 10mm X 4 mm. The microstrip feed line width used was 2.68mm. When we simulated this design we got a very narrow band but we found that this gave a multi band result. So we worked on improving the results.

We first changed the feed line width after calculating it in the Microstrip feed line calculator and found it to be 2.9mm. Next we reduced the thickness of the patch from 0.4mm to 0.05mm. The port was kept the same and the design was executed. This time we got a slightly improved result but still it did not give the desired bandwidth. Next after making a few more calculations we had to reduce the substrate length by 5mm from each side and adjusted the patch accordingly. We then changed the dimension of the port and simulated the design. This time we got a wide band and the result was satisfying.

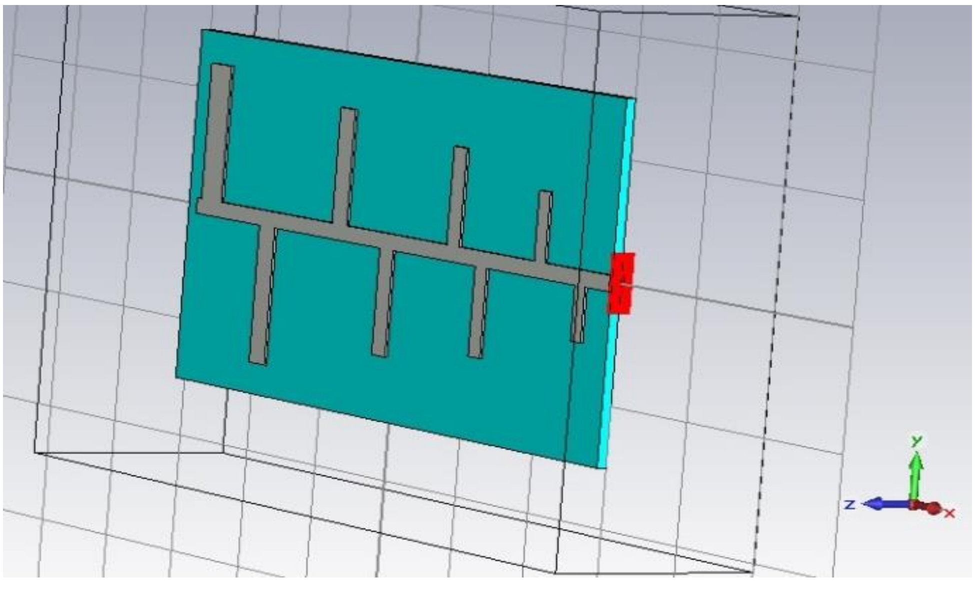
Fig: 3.2 Different views of the initially designed antenna



FRONT VIEW (Initial Design)



REAR VIEW (Initial Design)



PORTVIEW (Initial Design)

We used curves to design the patch and then extruded it to desired thickness. There were several changes made in the curve too, which may not be clear from the figures but can be known seeing the following coordinates of the curves.

Front side

X	Y
-57	1.34
-38.13	1.34
-38.13	24.68
-33.6	24.68
-33.6	1.34
-3.21	1.34
-3.21	19.16
0.62	19.16
0.62	1.34
23.59	1.34
23.59	16.22
26.88	16.22
26.88	1.34
50.89	1.34
50.89	10.4
53.57	10.4
53.57	1.34
56.57	1.34
56.57	-1.34
42.45	-1.34
42.45	-12.92
39.47	-12.92
39.47	-1.34
18.87	-1.34
18.87	-17.67
15.34	-17.67
15.34	-1.34
-13.05	-1.34
-13.05	-20.83
-17.26	-20.83
-17.26	-1.34
-49.83	-1.34
-49.83	-24.61
-55.75	-24.61
-55.75	-1.34
-57	-1.34
-57	1.34

Back side

X	Y
-57	1.34
-55.75	1.34
-55.75	24.61
-49.83	24.61
-49.83	1.34
-17.26	1.34
-17.26	20.83
-13.05	20.83
-13.05	1.34
15.34	1.34
15.34	17.67
18.87	17.67
18.87	1.34
39.47	1.34
39.47	12.92
42.45	12.92
42.45	1.34
56.57	1.34
56.57	-1.34
53.57	-1.34
53.57	-10.4
50.89	-10.4
50.89	-1.34
26.88	-1.34
26.88	-16.22
23.59	-16.22
23.59	-1.34
0.62	-1.34
0.62	-19.16
-3.21	-19.16
-3.21	-1.34
-33.6	-1.34
-33.6	-24.68
-38.13	-24.68
-38.13	-1.34
-57	-1.34
-57	1.34

Table: 3.2 Coordinates for the curve of front and back side in the initial design

Front side

X	Y
-55	1.45
-38.13	1.45
-38.13	23.68
-33.2	23.68
-33.2	1.45
-3.21	1.45
-3.21	19.01
0.62	19.01
0.62	1.45
23.59	1.45
23.59	16.22
26.88	16.22
26.88	1.45
50.89	1.45
50.89	10.89
53.57	10.89
53.57	1.45
55	1.45
55	-1.45
42.45	-1.45
42.45	-12.91
39.47	-12.91
39.47	-1.45
18.87	-1.45
18.87	-17.67
15.34	-17.67
15.34	-1.45
-13.05	-1.45
-13.05	-20.83
-17.78	-20.83
-17.78	-1.45
-48.83	-1.45
-48.83	-26.65
-54.75	-26.65
-54.75	-1.45
-55	-1.45
-55	1.45

Back side

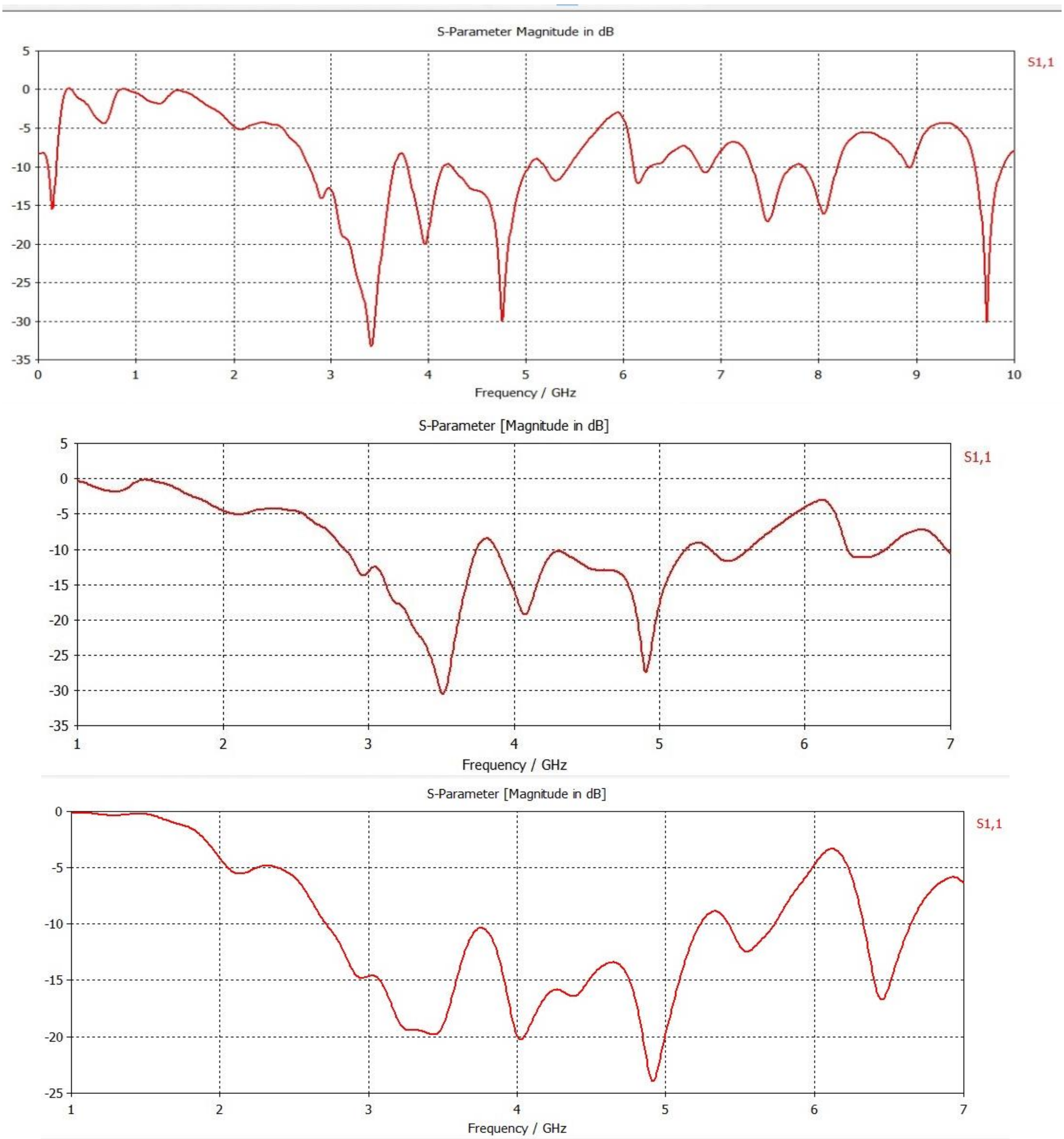
X	Y
-55	1.45
-54.75	1.45
-54.75	26.65
-48.83	26.65
-48.83	1.45
-17.78	1.45
-17.78	20.83
-13.05	20.83
-13.05	1.45
15.34	1.45
15.34	17.67
18.87	17.67
18.87	1.45
39.47	1.45
39.47	12.91
42.45	12.91
42.45	1.45
55	1.45
55	-1.45
53.57	-1.45
53.57	-10.89
50.89	-10.89
50.89	-1.45
26.88	-1.45
26.88	-16.22
23.59	-16.22
23.59	-1.45
0.62	-1.45
0.62	-19.01
-3.21	-19.01
-3.21	-1.45
-33.6	-1.45
-33.6	-23.68
-38.13	-23.68
-38.13	-1.45
-55	-1.45
-55	1.45

Table: 3.3 Coordinates for the curve of front and back side in the final design

Chapter 4 Observations and Calculations

4.1 Return Loss

The necessary modifications made in the design can be justified easily by seeing the following graphs.



Resonance frequency = 4.9021 GHz Bandwidth = 2.824 – 5.253 GHz

Fig: 4.1 a,b,c Graph showing return loss at various stages of designing

Here we have 3 graphs showing the return loss of the MLPA. In the 1st graph you can see that we do not get any clear wide band but we have numerous narrow bands instead. If we closely look at the plot we will notice that we can get a wide band from near 2.8 to 5.2 GHz if we can lower the 3 notches between. After making a few changes in the thickness of the patch and the port we could reach to the result which is shown in the 2nd graph. Here we see the 3rd notch has moved away and the 2nd notch has lowered below -10dB. So now we are left with only one notch. We know that if we increase the substrate area the bandwidth increases, so we tried increasing the length of the substrate by 5mm on each side. This made the graph spread wider on the surface no doubt but we did not get a clear wide band, rather the notches moved further high which was the opposite of what we desired for. So we again reduced the length further less than the original length by 5mm on both sides. After reducing the substrate we had to make some minor changes with the patch also to accommodate it within the patch. When all necessary changes were made we simulated the design and the result that we got is shown in the 3rd graph. In this graph we can see the notches are all below the -10dB mark. Thus we get a clear wide band from 2.824 GHz to 5.253 GHz.

4.2 VSRW

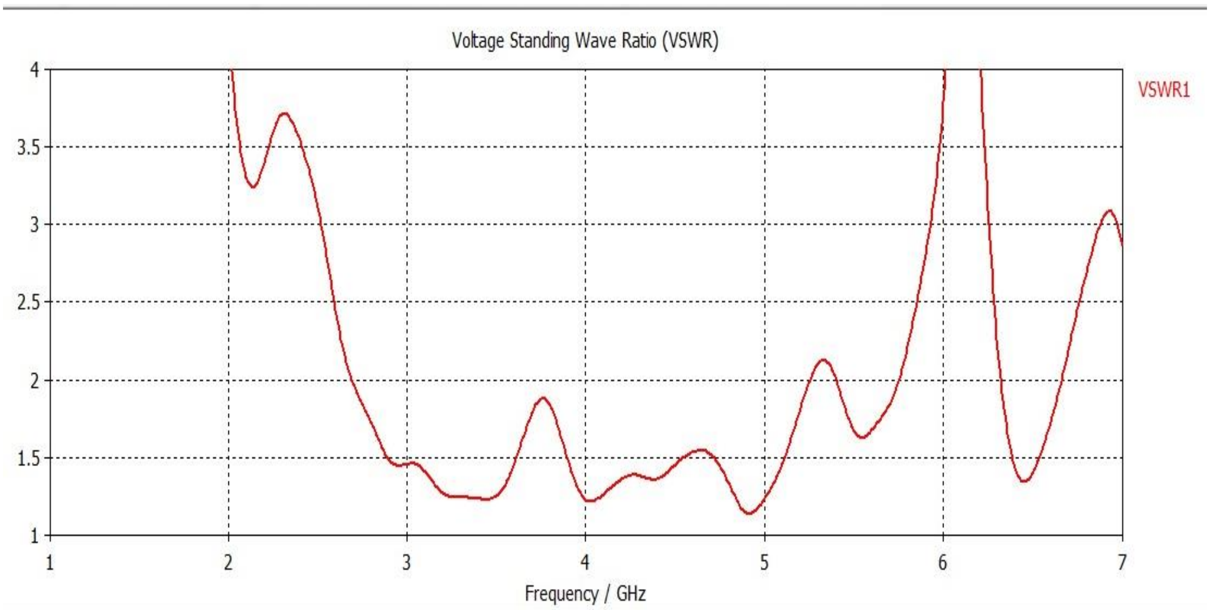


Fig: 4.2 Graph for VSWR

4.3 Radiation patterns:

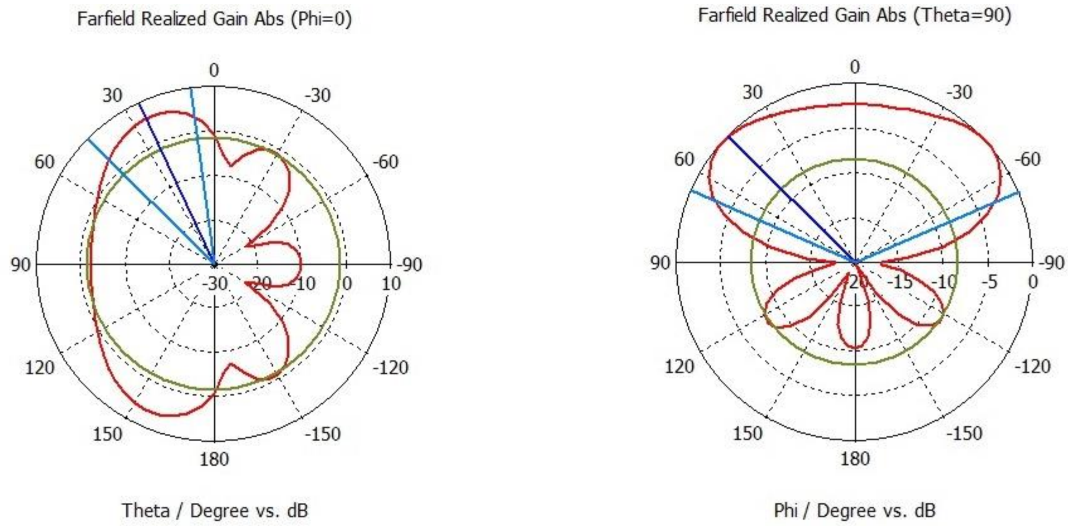


Fig: 4.3 a,b Radiation patterns: E- Plane and H - Plane
at resonant frequency = 4.9021 GHz

4.4 Gain:

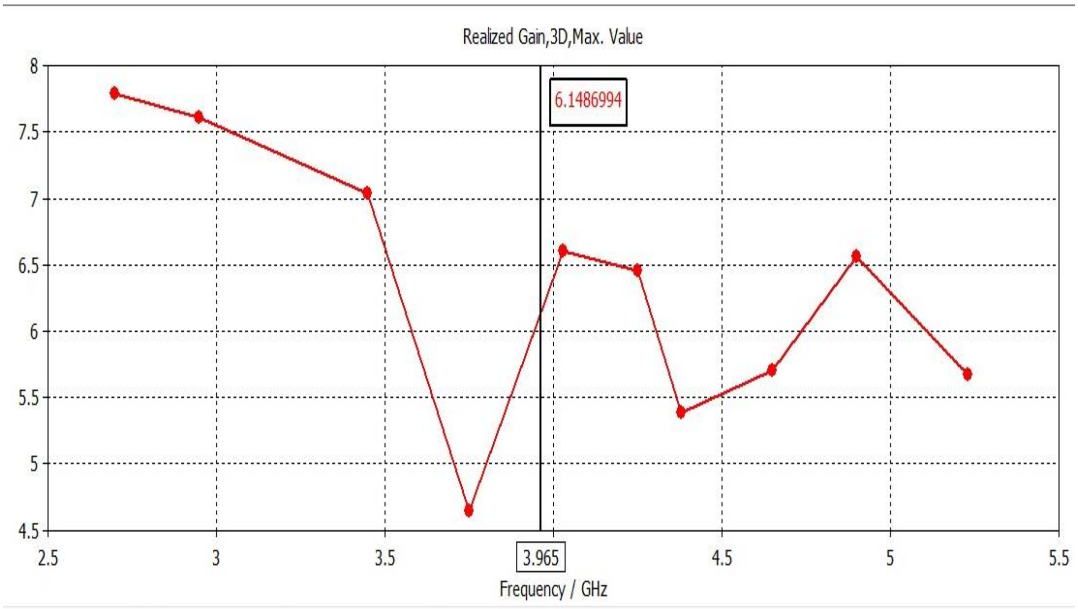


Fig: 4.4 Graph representing Realized Gain

4.5 Directivity:

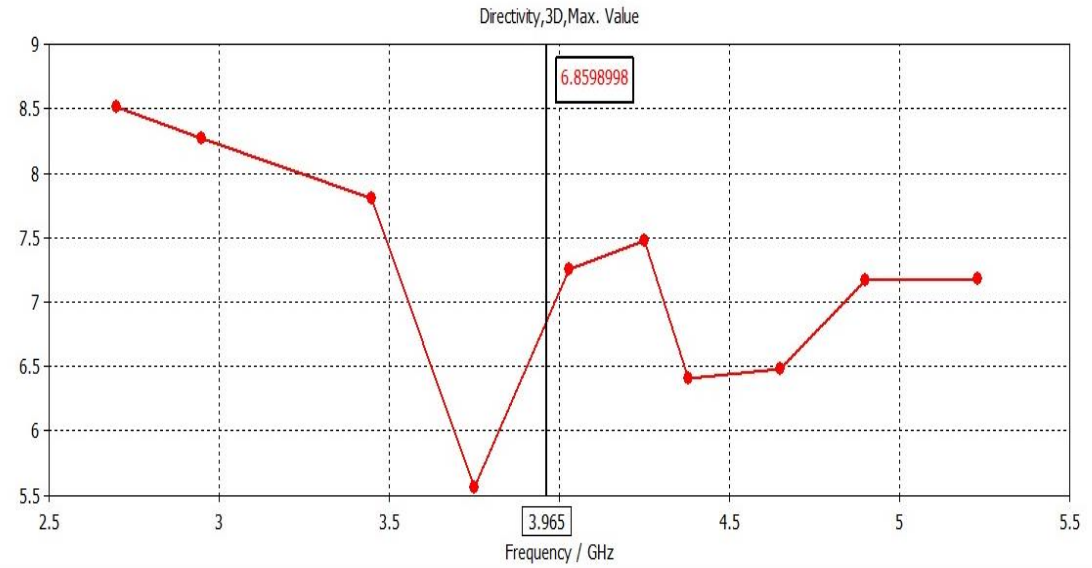


Fig: 4.5 Graph for Directivity

4.6 Front to Back Ratio:

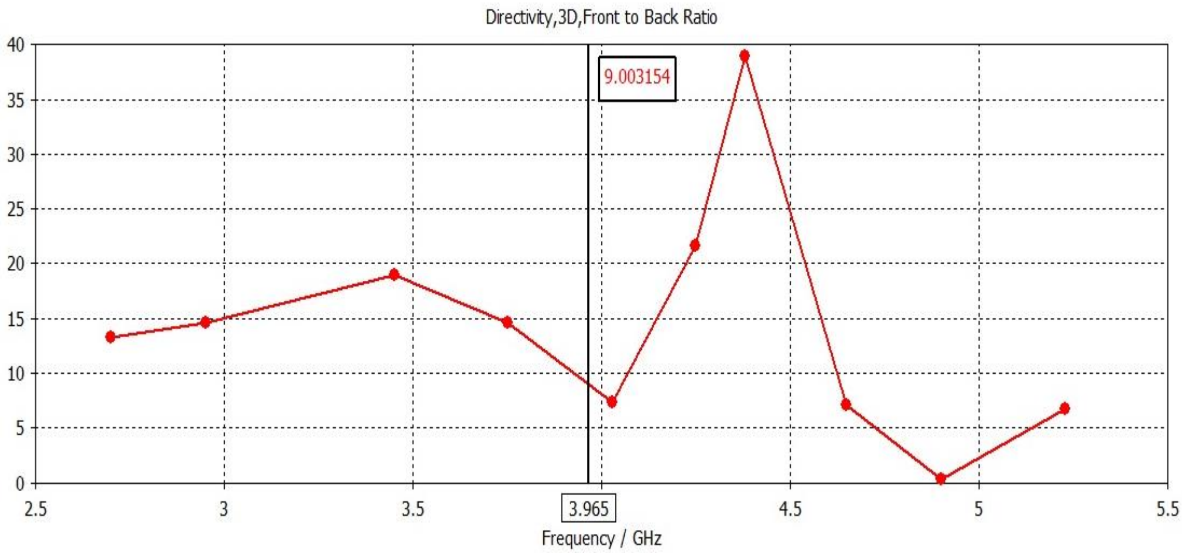


Fig: 4.6 Graph for Front to Back Ratio

4.7 Efficiency:

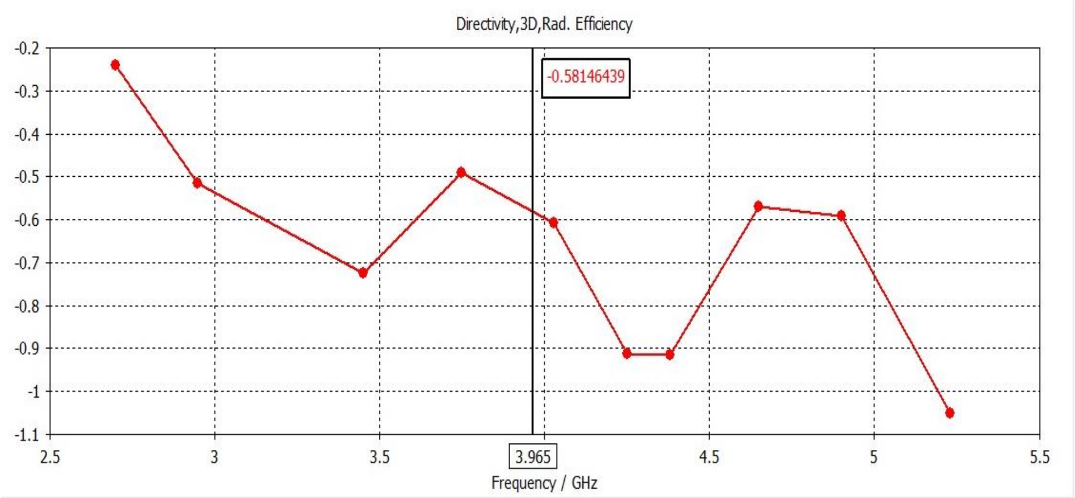


Fig: 4.7 Radiation Efficiency Graph

4.8 Calculations:

Lower cut off frequency = f1 = 2.823 GHz

Higher cut off frequency = f2 = 5.254 GHz

% Band-Width= $\frac{f2-f1}{\sqrt{f1.f2}}$*100%

= $\frac{5.253-2.824}{\sqrt{5.253*2.823}}$*100%

= 29.92%

The above frequency range lies under S-band and C-band.

Chapter 5 Conclusion:

We designed and simulated a Microstrip Log Periodic Antenna (MLPA) using CST Microwave Studio Suite 2012. The antenna operated at a resonant frequency of 4.9021 GHz. The range pf the MLPA was found to be between 2.824 GHz to 5.253 GHZ. This range lies partially within the S-band and C-band. It has a bandwidth of 29.921%. This antenna can be used for satellite communication, amateur radio broadcasting, providing Wi-fi channels and many other purposes because of its broadband, direction radiation, light weight, low profiles, and easily-integrated performance.

Future Work:

With the help of Impedance Matching, each bar of the antenna can be added with a matched section and the bandwidth can be further enhanced. Ones the bandwidth is enhanced the antenna can be fabricated and brought into practical use.

References

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